RESEARCH HIGHLIGHTS

Technical Series 01-138

INNOVATIVE ON-SITE WASTEWATER TREATMENT

Introduction

Densely developed suburban areas and small communities are increasingly relying on septic systems, as funds for large infrastructure projects have become more scarce. Problems with residential septic systems, however, are common across Canada.

Surface breakouts, back-ups into houses and contamination of groundwater supplies are evidence of system failures. Such problems arise from excessive water usage and lack of maintenance, inadequate site assessment—especially in marginal soils, outdated design practices, or poor construction.

To gain a better understanding of appropriate design and construction techniques, and demonstrate wastewater nutrient removal technologies, Canada Mortgage and Housing Corporation funded development of an innovative residential wastewater disposal system in rural Nova Scotia. Approximately 40 per cent of the province's population dispose of household waste into septic tanks and infiltration field systems.

The installation included a site assessment, use of water efficient fixtures in the house, septic tank insulation and filtering, a Waterloo biofilter, effluent recirculation, a denitrification filter and disposal of the treated wastewater in a contour trench.

Methodology

The site chosen was located in Lunenburg County, Nova Scotia. The lot measured 38 m by 76 m with an approximate 10 per cent slope towards the well treed back.

The single-family, one bathroom house, was fitted with a 6 L toilet, a low-flow showerhead and faucet aerators. The water supply came from a drilled well in the front yard between the house and the road. Water meters on the main line and the exterior tap line allowed for monitoring of all water use and calculation of the system loading rate.

Proper design of the soil absorption system is critical for successful treatment and disposal of household wastewater. Site evaluation is therefore a critical step. The suitability of the soil was assessed using two inspection pits and in-situ assessment of hydraulic conductivity. The results indicated that a contour trench should be used for the disposal field, and the system was installed as shown in figure 1.

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Figure 1: Plan view of lot and disposal system

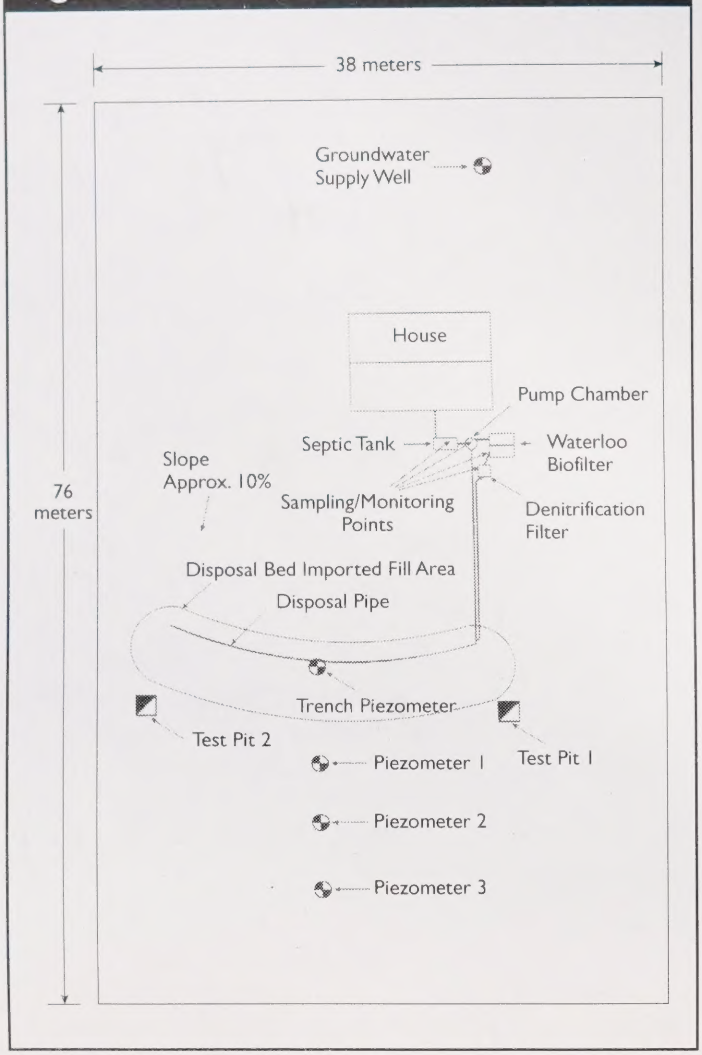
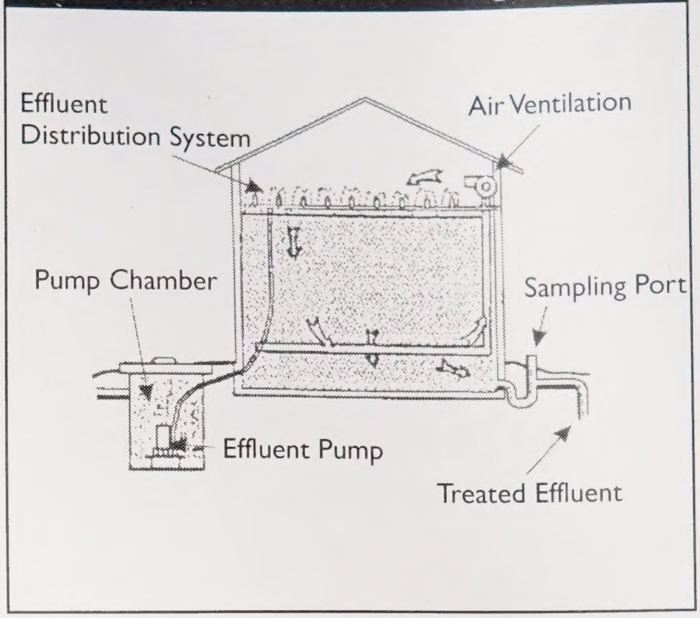


Figure 2: Waterloo biofilter configuration



In addition to the low-flow fixtures reducing wastewater flows by 3 per cent, a number of technologies were used to reduce wastewater impact on the soil below the bed. This included insulating the 3,600 L septic tank and the 900 L pump chamber immediately downstream to improve biological breakdown of the effluent. A removable effluent filter in the septic tank restricted movement of solids to the disposal field.

From the pump chamber, the effluent flowed to the Waterloo biofilter, where aerobic breakdown took place. Structurally, this biofilter is an insulated plywood box 1.8 m x 1.8 m x 1.2 m high and capped with a hinged roof, as shown in Figure 2. Hardwood pellets were used as the denitrification media. A thick sheet of polyurethane foam on top limited oxygen migration into the pellet layer.

The pellets expanded by roughly 100 per cent when they became wet, clogging the filter. Corrective action included excavation of the system and removal of excess pellets.

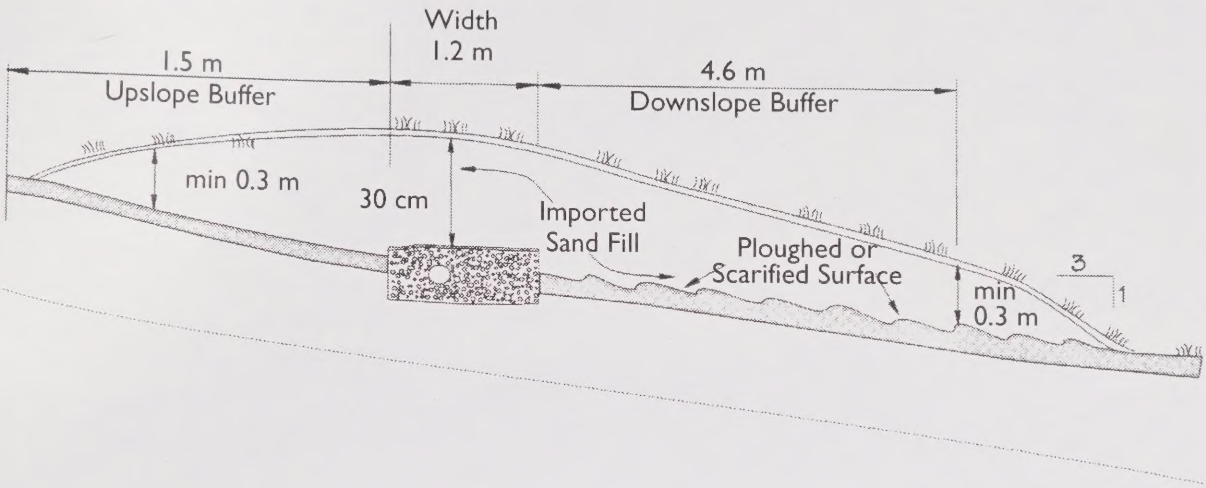
Interestingly, a saturated (clogged) flow proved significantly more effective in nitrate removal than an unsaturated (unclogged) flow. An inverted U-trap was subsequently installed on the outflow pipe. This raised the level of effluent in the filter, resulting once again in anaerobic conditions and assuring optimum nitrate removal.

From the biofilter, the treated effluent flowed by gravity out through a collection pipe in the floor to a denitrification filter and then to the disposal bed.

The disposal trench was 24 m long by 1.2 m wide and 0.2 m deep at the toe. A cross section of the design is shown in figure 3. Clean sand was laid at the bottom of the trench. As effluent is dosed to the bottom of the trench, an organic slime layer, known as a biomat, eventually forms at the crushed rock and sand interface, becoming a hydraulic barrier setting the long-term acceptance rate of the effluent.

Samples were collected and analyzed for ammonia, nitrate+nitrate, kjeldhal nitrogen, suspended solids, biological oxygen demand (BOD), total phosphorus, pH, and total and fecal coliforms.

Figure 3: Contour disposal field cross-section



Sampling was done on a weekly basis for the first five weeks of operation in late 1994, when it became apparent that the pump had failed due to improper installation. After replacing the pump and control panel, sampling proceeded on a monthly basis from February to December 1995 inclusive, and then every two months from February through October 1996 when a recirculation process was introduced.

Recirculation contributes to reducing nitrogen from the wastewater stream. Denitrification is facilitated by a low oxygen environment in which a carbon source is present, the very conditions that exist in a septic tank. A distribution box installed between the biofilter and the denitrification filter sent two-thirds of the effluent back to the pump chamber, with the remaining third flowing to the disposal field.

Final monitoring occurred during 1997, with samples being taken every two months from January through November for a total of five samples.

Results

Water conserving fixtures reduced the hydraulic load on the system by 30 per cent over average values. Typical flow values for a family of four would be about 820 L per day, whereas the average daily flow for this demonstration project was 580 L.

However, reduced water consumption may have been the cause of some higher chemical concentrations in the effluent. BOD levels were higher than average to begin with, but gradually decreased over time, approaching normal levels. Significant reductions in BOD were particularly noticeable in the final three samples taken, from which it can be concluded that recirculation had a positive effect in reducing BOD. Installation of the recirculation system also resulted in reduced concentrations in both total and fecal coliforms in the pump chamber and after the denitrification filter.

Ammonia and kjeldhal nitrogen values were also above typical domestic levels, although ammonia values steadily decreased during the initial monitoring period to levels typical of domestic effluent. Significantly better nitrification results had been obtained from biofilters at other locations, so it was suspected that the high levels of BOD in this effluent hindered the nitrification process.

Overall though, the results were encouraging. After passing through the biofilter, the effluent showed removal rates of 95 per cent for BOD, 58 per cent for phosphorous, 19 per cent for suspended solids and 94 per cent for fecal coliforms.

The septic tank filter proved effective in blocking movement of lint and large solids from the tank into the disposal field. Removing and rinsing the filter is much easier than having to remove solids from disposal bed pipes, gravel or soil pores.

The project demonstrated the necessity of ensuring anaerobic conditions in the denitrification filter to optimize nitrate removal. The filter reduced post-biofilter total nitrogen load a further 15 to 35 per cent prior

to subsurface disposal. This is particularly important for nutrient-sensitive disposal environments. However, the denitrification filter design for this project would not likely be commercially viable without modification to reduce maintenance requirements for regular operation.

Conclusion

This project demonstrated that residential septic systems, properly designed, can effectively treat and safely dispose of wastewater with no contamination of groundwater or soil. By incorporating technologies and design features that substantially reduce effluent nitrates, such systems can help protect environmentally sensitive areas.

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Housing Research at CMHC

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